MP142E

# N-111 NEXLINE® Linear Actuator

## User Manual

Version: 1.0.0 Date: 15.06.2015

**This document describes the following products:**

- **N-111.201**
  NEXLINE®OEM Piezo Stepping Actuator, 10 mm, 50 N
- **N-111.2A1**
  NEXLINE®OEM Piezo Stepping Actuator, 10 mm, 50 N, Linear Encoder, 5 nm Resolution



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The products described in this document are in part protected by the following patents:

German patent no. 10148267B4

US patent no. 6,800,984B2

European patent no. 1267478B1

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Subject to change without notice. This manual is superseded by any new release. The latest release is available for download (p. 3) on our website.

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# 1 About this Document

## In this Chapter

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## 1.1 Goal and Target Audience of this User Manual

This manual contains information on the intended use of the N-111.

It assumes that the reader has a fundamental understanding of basic servo systems as well as motion control concepts and applicable safety procedures.

The latest versions of the user manuals are available for download (p. 3) on our website.

## 1.2 Symbols and Typographic Conventions

The following symbols and typographic conventions are used in this user manual:

***CAUTION***

**Dangerous situation**

If not avoided, the dangerous situation will result in minor injury.

➢ Actions to take to avoid the situation.

***NOTICE***

**Dangerous situation**

If not avoided, the dangerous situation will result in damage to the equipment.

➢ Actions to take to avoid the situation.

***INFORMATION***

Information for easier handling, tricks, tips, etc.

| Symbol/ Label | Meaning |
|---|---|
| 1.<br>2. | Action consisting of several steps whose sequential order must be observed |
| ➢ | Action consisting of one or several steps whose sequential order is irrelevant |
| ▪ | List item |
| p. 5 | Cross-reference to page 5 |
| **RS-232** | Labeling of an operating element on the product (example: socket of the RS-232 interface) |
| | Warning signs affixed to the product that refer to detailed information in this manual. |

## 1.3 Figures

For better understandability, the colors, proportions and degree of detail in illustrations can deviate from the actual circumstances. Photographic illustrations may also differ and must not be seen as guaranteed properties.

## 1.4 Other Applicable Documents

The devices and software tools which are mentioned in this documentation are described in their own manuals.

| Product | Document |
|---|---|
| E-712 Digital Piezo Controller | PZ195E User Manual |
| PIMikroMove | SM148E Software Manual |

## 1.5 Downloading Manuals

***INFORMATION***

If a manual is missing or problems occur with downloading:

➢ Contact our customer service department (p. 35).

***INFORMATION***

For some products (e.g. Hexapod systems and electronics that are delivered with a CD), access to the manuals is password-protected. The password is stored on the CD. Availability of the manuals:

- Password-protected manuals: FTP download directory
- Freely available manuals: PI website

➢ Follow the corresponding instructions for downloading.

### Downloading freely accessible manuals

1. Open the website **http://www.pi-portal.ws**.
2. Click ***Downloads***.
3. Click the corresponding product category.
4. Go to the corresponding product code.

   The available manuals are displayed.
5. Click the desired manual and save it on the hard disk of your PC or on a data storage medium.

### Downloading password-protected manuals

1. Insert the product CD in the PC drive.
2. Switch to the Manuals directory on the CD.
3. In the Manuals directory, open the Release News (file including ***releasenews*** in the file name).
4. Find the user name and the password in the section "User login for software download" in the Release News.
5. Open the FTP download directory (ftp://pi-ftp.ws).
   - Windows operating systems: Open the FTP download directory in Windows Explorer.

6. Log in with the user name and the password from the Release News.
7. In the directory of the corresponding product, go to the Manuals sub-directory.
8. Copy the desired manual to the hard disk of your PC or to a data storage medium.

# 2 Safety

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## 2.1 Intended Use

Based on its design and realization, the N-111 is intended for single-axis positioning, adjusting and shifting of loads at various velocities.

The N-111 is a laboratory device as defined by DIN EN 61010-1. It is intended to be used in interior spaces and in an environment which is free of dirt, oil, and lubricants.

The intended use of the N-111 is only possible when installed and in connection with a suitable controller (p. 12). The controller is not included in the scope of delivery of the N-111.

## 2.2 General Safety Instructions

The N-111 is built according to state-of-the-art technology and recognized safety standards. Improper use can result in personal injury and/or damage to the N-111.

- Only use the N-111 for its intended purpose, and only use it if it is in a good working order.
- Read the user manual.
- Immediately eliminate any faults and malfunctions that are likely to affect safety.

The operator is responsible for the correct installation and operation of the N-111.

## 2.3 Organizational Measures

### User manual

- Always keep this user manual available by the N-111.
  The latest versions of the user manuals are available for download (p. 3) on our website.
- Add all information given by the manufacturer to the user manual, for example supplements or Technical Notes.
- If you pass the N-111 on to other users, also turn over this user manual as well as other relevant information provided by the manufacturer.
- Only use the device on the basis of the complete user manual. Missing information due to an incomplete user manual can result in minor injury and property damage.
- Only install and operate the N-111 after having read and understood this user manual.

### Personnel qualification

The N-111 may only be installed, started up, operated, maintained and cleaned by authorized and appropriately qualified personnel.

# 3 Product Description

## In this Chapter

Features and Applications ..... 7
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Scope of Delivery ..... 12
Suitable Controllers ..... 12
Only N-111.2A1: Technical Features for Closed-Loop Operation ..... 12

## 3.1 Features and Applications

- Travel range 10 mm
- High push and holding forces (50 N / 70 N)
- High position resolution
- PiezoWalk® principle
- Self-locking, thus no holding currents and no heat generation at rest
- Non-magnetic function principle
- Can also be used in environments with:
  - Clean room requirements
  - Strong magnetic fields
  - Strong UV radiation
  - Vacuum (modified products up to 0.1 hPa, on request)

The N-111 NEXLINE® OEM linear actuator is a compact drive for nanopositioning technology. The feed is generated by coordinated shearing and clamping motions of strongly preloaded piezo elements that are coupled to a rod (PiezoWalk® principle). In this way, NEXLINE® drives combine relatively long travel ranges with the nanometer precision of piezo actuators.

The N-111.2A1 is equipped with a linear encoder for direct measurement of the rod position. The resolution here is 5 nm over the entire travel range (closed-loop operation).

In highly dynamic analog operation, position resolutions up to 25 pm can be achieved (open-loop operation).

The linear actuator supports the following modes of operation for positioning a load:

| Operating Mode | Advantages |
|---|---|
| Full step mode | ▪ Long travel ranges<br>▪ High velocity<br>▪ High dynamic forces |
| Nanostepping mode | ▪ Long travel ranges<br>▪ Low vibration<br>▪ Uniformity of motion |
| Analog mode | ▪ Travel ranges in the µm range<br>▪ High dynamics<br>▪ High resolution |

➢ Further details on the operating modes are found in the manual of the controller used.

## 3.2 Model Overview

Two standard versions of the N-111 NEXLINE® OEM linear actuator are available. They differ regarding the presence of an integrated sensor and thus in height.

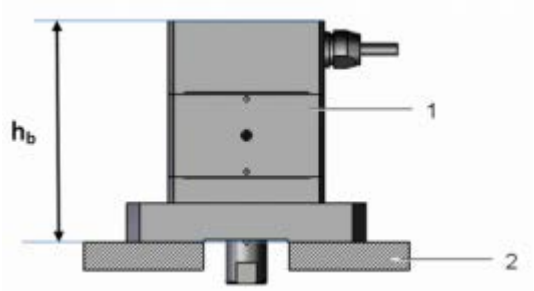


*Figure 1: Height hb*

*1 Actuator*
*2 Surface (part of the application)*
*$h_b$ Height*

| Model | Characteristics |
|---|---|
| N-111.201 | NEXLINE® OEM piezo stepping actuator, travel range 10 mm, max. push force 50 N, overall height $h_b$ 42.5 mm |
| N-111.2A1 | NEXLINE® OEM piezo stepping actuator, travel range 10 mm, max. push force 50 N, with linear encoder, 5 nm resolution, overall height $h_b$ 62 mm |

- For further technical data, see the specifications (p. 37).

PI also produces custom designs upon request. Custom designs can differ from the described standard products in respect to dimensions, characteristics or other technical data.

- If necessary, contact our customer service department (p. 35) directly.

## 3.3 Product View

### 3.3.1 Overview

*Figure 2: Linear actuators N-111.2A1 (left) and N-111.201 (right)*

## 3.3.2 Product Details

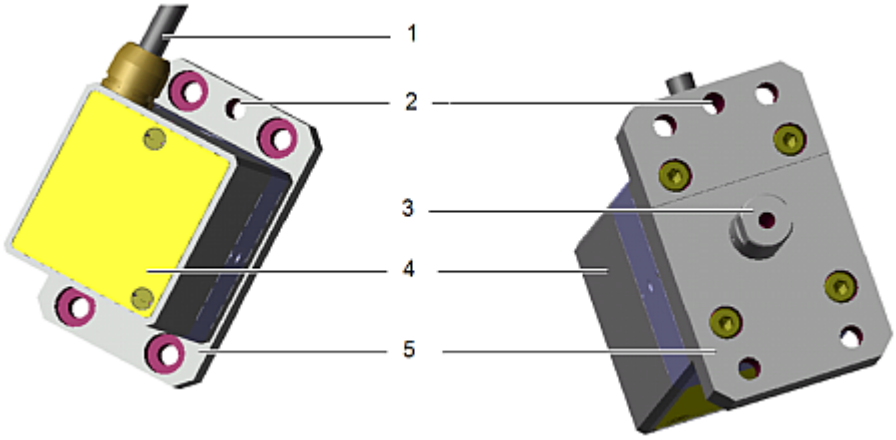


*Figure 3: Position of important elements, top and bottom view of actuator case (schematic, components marked in color)*

*1 Connection cable*
*2 Protective earth connection*
*3 Rod (non-rotating)*
*4 Actuator case*
*5 Mounting plate*

### 3.3.3 Product Labeling

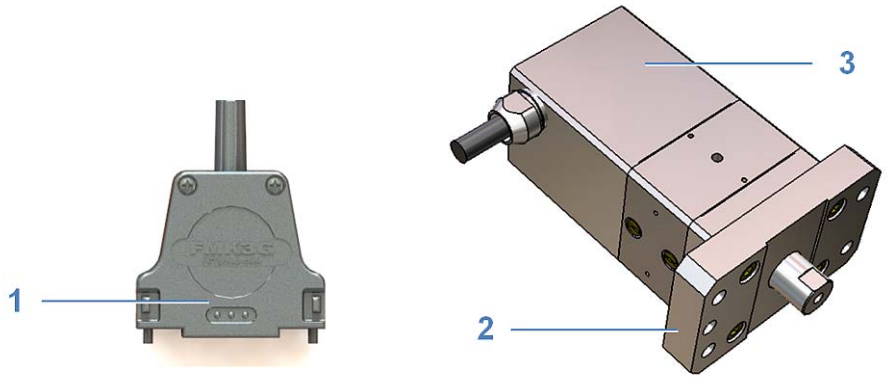


*Figure 4: Position and appearance of the product labels*

| Position | Labeling | Description |
|---|---|---|
| 1 | ⚠ | Warning sign "Attention! Residual voltage" |
| 2 | ⏚ | Symbol for the protective earth conductor, marks the protective earth connection of the N-111 (p. 22) |
| 3 | N-111.2A1 | Product name (example), the places after the point refer to the model |
| 3 | 113055789 | Serial number (example), individual for each N-111<br>Meaning of the places (counting from left): 1 = internal information, 2 and 3 = manufacturing year, 4 to 9 = consecutive numbers |
| 3 | ⚠ | Warning sign "Observe manual!" |
| 3 | | Old equipment disposal (p. 47) |
| 3 | Country of origin: Germany | Country of origin |
| 3 | WWW.PI.WS | Manufacturer's address (website) |
| 3 | PI | Manufacturer's logo |
| 3 | CE | CE conformity mark |

## 3.4 Scope of Delivery

The N-111 is delivered with the following components:

| Order number | Component |
|---|---|
| N-111.2x1 | Linear actuator according to order |
| 000036450 | M4 screw set for protective earth connection |
| MP142E | User manual (this document) in printed form |
| | Packaging materials |

## 3.5 Suitable Controllers

| Controller | Description |
|---|---|
| E-712.1AM | Digital Motion Controller, 1 Channel, for NEXLINE®Nanopositioning Linear Drives with Incremental Encoder |

## 3.6 Only N-111.2A1: Technical Features for Closed-Loop Operation

### 3.6.1 Linear Encoder (Sensor)

The linear actuator is equipped with an optical linear encoder. For the encoder resolution, refer to the table in the "Specifications" section (p. 37).

Optical linear encoders measure the actual position directly (direct metrology). Therefore, errors occurring in the drivetrain, such as nonlinearity, backlash or elastic deformation, cannot influence the measurement of the position.

### 3.6.2 Reference Point Switch

The linear actuator is equipped with a direction-sensing reference point switch that is located approximately in the middle of the travel range. This sensor transmits a TTL signal that indicates whether the linear actuator is on the positive or negative side of the reference point switch.

The commands that use the reference signal are described in the user manual of the controller and/or in the corresponding software manuals.

# 4 Unpacking

1. Unpack the N-111 with care.
2. Compare the contents against the items covered by the contract and against the packing list.
3. Inspect the contents for signs of damage. If parts are missing or you notice signs of damage, contact PI immediately.
4. Keep all packaging materials in case the product needs to be returned.

# 5 Installation

## In this Chapter

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## 5.1 Providing a Suitable Installation Environment

### Installation recommendation

The N-111 is intended for being screwed into a level surface, a base body or a case (referred to in general as "surface" in the following).

Alternatives for mounting holes (see also the following figures):

- **Threaded holes** in the surface
- **Through holes** in the surface

The following instructions for preparing and carrying out the fastening refer to an installation with threaded holes.

➢ If you use other designs, proceed correspondingly.

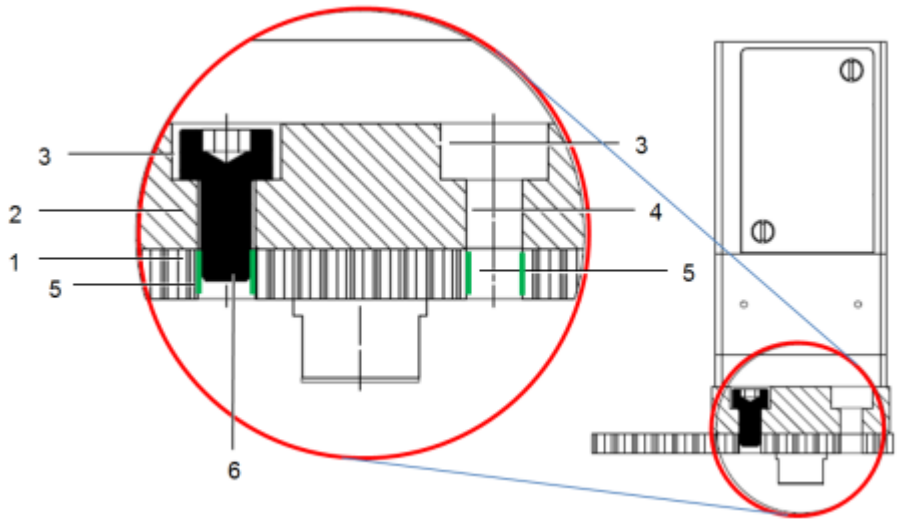


*Figure 5: Recommended fastening on the surface (cross sectional drawing, only one screw is screwed in for better representation)*

*1 Surface*
*2 Mounting plate of the linear actuator*
*3 Counterbore*
*4 Through hole for M3 (in the mounting plate of the linear actuator)*
*5 M3 threaded hole (in the surface)*
*6 Fastening screw: Cylinder head, M3 (ISO 4762)*

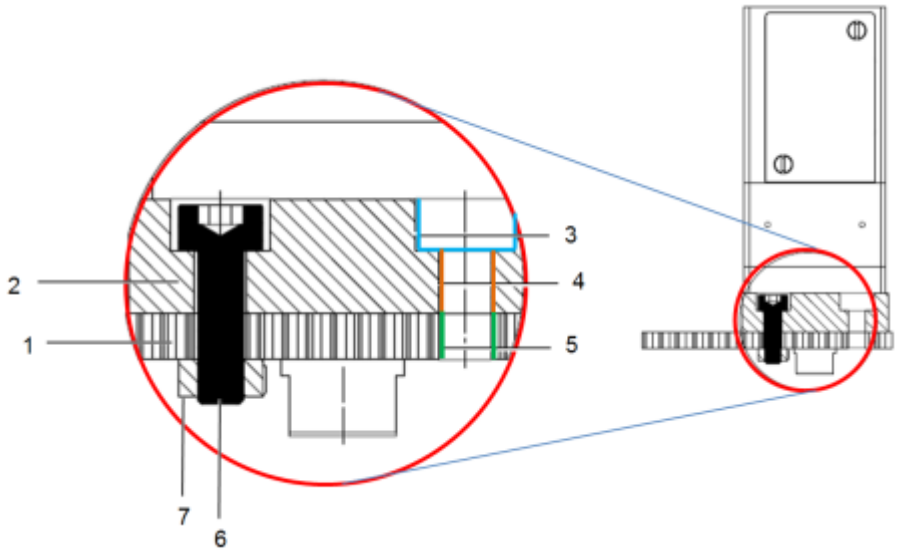


*Figure 6: Example of alternative to recommended fastening (with through hole in the surface and nut)*

1 *Surface*
2 *Mounting plate of the linear actuator*
3 *Counterbore*
4 *Through hole for M3 (in t he mounting plate of the linear actuator)*
5 *Through hole for M3 (in the surface)*
6 *Fastening screw: Cylinder head, M3 (ISO 4762)*
7 *M3 nut*

## Providing a suitable installation environment

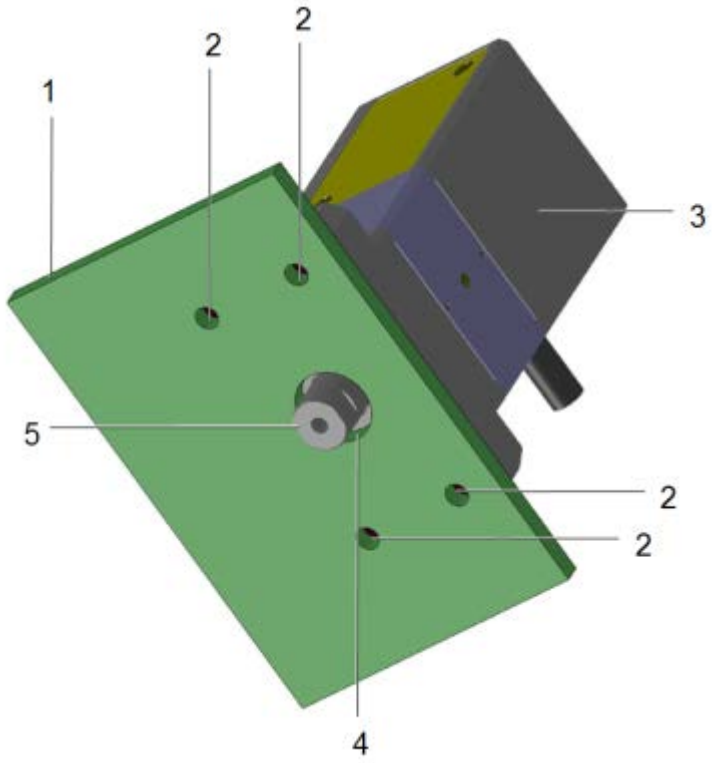


*Figure 7: Linear actuator on surface (schematic); relevant components*

1 *Surface (section)*
2 *M3 threaded hole*
3 *Case of the linear actuator*
4 *Feedthrough for rod (here: hole 10 mm coaxial to the motion axis of the rod)*
5 *Rod of the linear actuator*

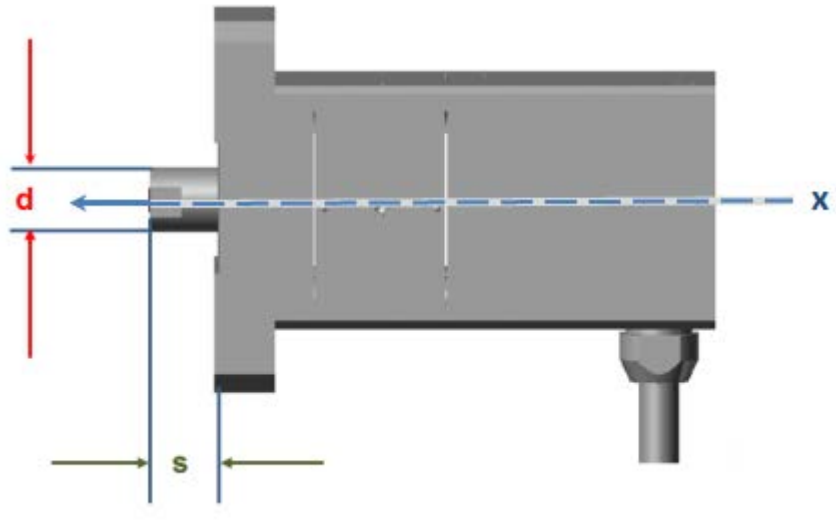


*Figure 8: Relevant rod dimensions*

*d* *Diameter of the rod: 8 mm*

*s* *Distance between rod end - lower edge of the mounting plate*
*- with full use of the travel range: 3 mm to 13 mm,*
*- at center position: 8 mm (delivery state, switching point for reference point switch in the N-111.2A1)*

*x* *Motion axis of the rod*

You can obtain all dimensions of the linear actuator and relevant individual parts in the section "Dimensions" (p. 42).

The intended use of the linear actuator requires a suitable installation environment.

➢ Make sure that the following conditions are met:

- Material and statics of the surface and the screw connections (fastening screw / hole system) are designed so that the static and dynamic forces that occur can be safely and continuously managed.
- Four M3 threaded holes and a feedthrough for the rod have been made in the surface.
- The distances between the holes in the surface match the distances between the mounting holes of the linear actuator (dimensions see p. 42).
- The depth of each hole is adapted to the length of the screws so that the linear actuator can be completely screwed in.

  - The position and size of the feedthrough for the rod prevent the rod from touching the surface after mounting (position and dimensions of the rod see p. 42 and above figure).
  - The ambient conditions do not exceed the ranges that are given in the specification for the N-111 (see Technical Data (p. 37)).

- When planning the application and installing the linear actuator, take account of the space required for routing the cables without kinks and in accordance with regulations:
  - Length of the connection cable: approx. 1.5 m
- If necessary, provide measures to limit or compensate for undesirable forces and torques (example: gravity compensation in the case of vertical mounting).
- If possible, perform a graphic simulation of the intended actuator motions with a mounted load or suitable calculations, in order to identify possible collisions within the application.
- If necessary, implement suitable design- or control-related measures to avoid collisions during operation of the linear actuator.
  Example:
  Collisions of the load with the surface when the rod is moved inwards can be avoided by the following measures:
  - Spacers (flat washers or sleeves) between the rod and load
  - Reduced thickness of the surface
  - Limitation of the travel range in the PC software
- In accordance with legal regulations, avoid or label danger areas that result from installation of the linear actuator and from use (e.g., risk of crushing in the case of heavy moving loads, fast actuator motions and/or high drive torques).

## 5.2 Mounting the N-111

***INFORMATION***

For optimum repeatablity, all components must be firmly affixed to each other.

### Tools and accessories

- Four M3 cylinder head screws (ISO 4762) with suitable length
- Suitable screwdriver or hexagonal key

### Prerequisites

✓ You have provided a suitable installation environment (p. 15).

✓ The linear actuator is **not** connected to the controller.

### Mounting the N-111

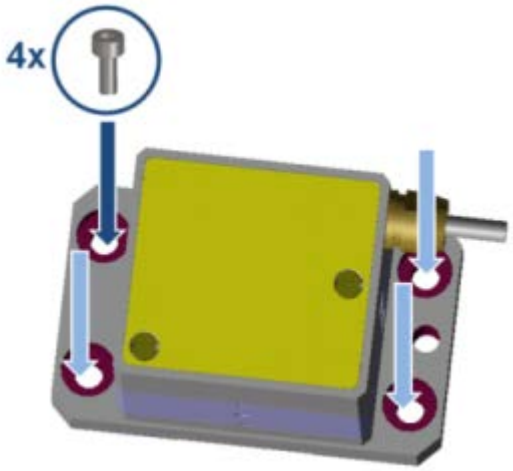


*Figure 9: Position of the mounting holes, schematic*

1. Position the mounting holes in the mounting plate of the linear actuator (see figure) over the corresponding holes in the surface.
2. Completely screw in the cylinder head screws at all mounting holes.
3. Check that the linear actuator fits on the surface without backlash.

## 5.3 Connecting the N-111 to the Protective Earth Conductor

***INFORMATION***

➢ Observe the applicable standards for mounting the protective earth conductor.

***INFORMATION***

➢ The hole for the protective earth connection is marked on the product p. 11.

### Tools and accessories

- Suitable protective earth conductor: conductor cross-section ≥ 0.75 $mm^2$, insulation green/yellow
- M4 screw set (included in the scope of delivery of the linear actuator)
- Philips-head screwdriver (PH 2)

### Connecting the N-111 to the protective earth conductor

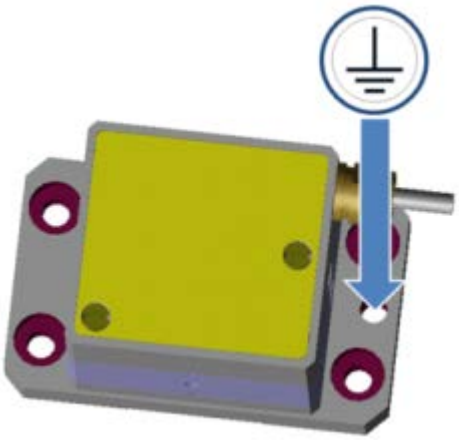

*Figure 10: Position of the protective earth connection*

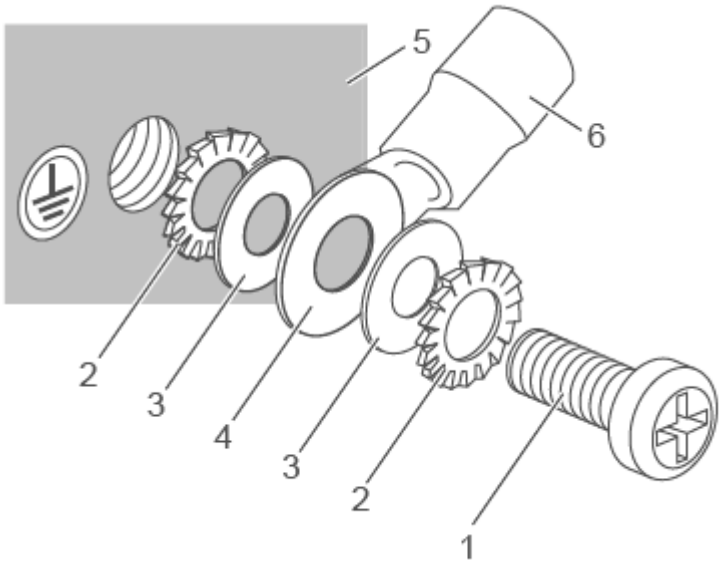


*Figure 11: Mounting of protective earth connection (schematic)*

1 *M4 screw*
2 *Toothed washer*
3 *Flat washer*
4 *Cable lug*
5 *linear actuator case with protective earth connection (M4 threaded hole) and protective earth conductor symbol*
6 *Protective earth conductor*

1. If necessary, fasten a suitable cable lug to the protective earth conductor.
2. Remove the screw, the toothed washers and flat washers from the package of the screw set.
3. As shown in the above figure: fasten one flat washer and one toothed washer each above and below the protective earth conductor or its cable lug with the screw on the protective earth connection of the linear actuator (position of the protective earth connection on the linear actuator: see figure above).
4. Tighten the screw with a torque of 1.2 Nm to 1.5 Nm.
5. Make sure that the protective earth conductor of the linear actuator is properly connected with the existing protective earth system within your application at all times.

## 5.4 Affixing the Load to the N-111

***NOTICE***

**Impermissibly high load on the linear actuator**

Impermissibly high loads inhibit the motion of the rod and can damage or destroy the linear actuator.

➢ With respect to mass and fastening type of the load, observe the maximum permissible active and passive forces and the resulting torques that are allowed to act on the rod according to the specification (p. 37).

***INFORMATION***

For optimum repeatablity, all components must be firmly affixed to each other.

### Prerequisites

✓ You have properly fastened the linear actuator according to the corresponding instructions (p. 21).

✓ The linear actuator is **not** connected to the controller.

### Tools and accessories

- M3 fastening screw with suitable length (depth of the threaded hole: 5 mm; further dimensions see p. 42).
- If necessary: Spring washer(s) or M3 flat washer(s)
- Open-end wrench, AF 7
- Suitable screwdriver, hexagonal key or open-end wrench for the fastening screw

## Affixing load to the N-111

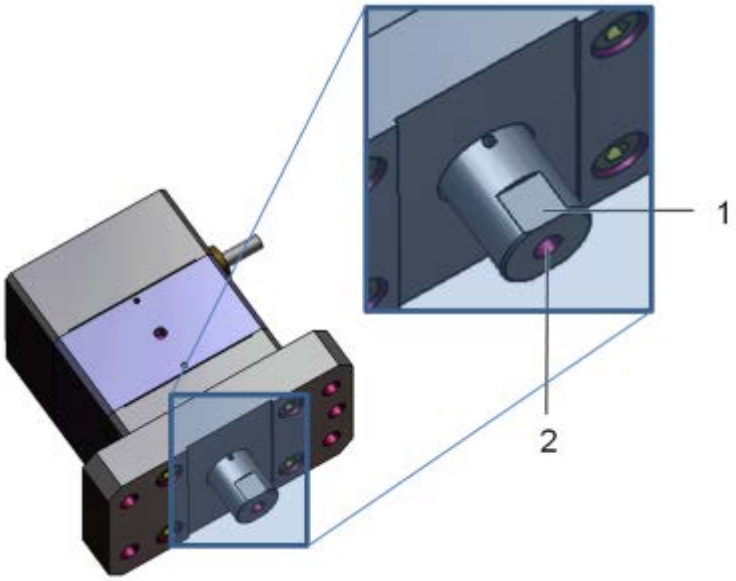


*Figure 12: Relevant components of the rod for affixing the load*

*1 Wrench flat* of the rod*

*2 M3 threaded hole for affixing the load*

** There is a further, parallel wrench flat on the rod that is symmetrical to the threaded hole and at a distance of 7 mm from the wrench flat shown (hidden in the above view).*

1. Attach the rod: Apply the open-end wrench to the wrench flats of the rod.
2. Affix the load on the threaded hole in the rod of the linear actuator with the fastening screw and, if necessary, attached spacers, safety washers or spring washers:
   Screw in the screw until you feel a resistance and tighten the screw with a torque of 1.1 Nm.
3. Check that the load is affixed firmly.

## 5.5 Connecting the N-111 to the Controller

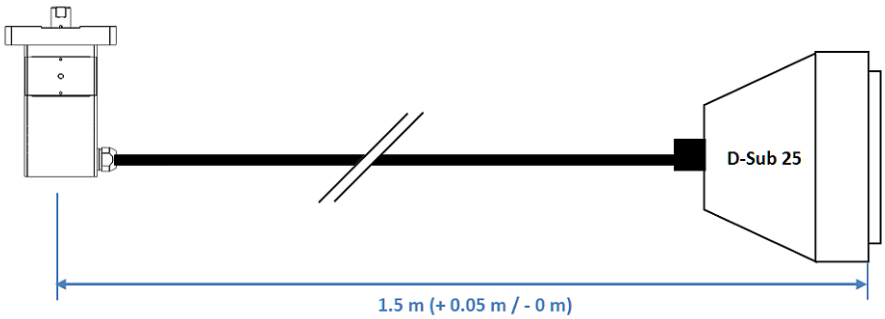


*Figure 13: Cabling diagram*

### Prerequisites

- ✓ You have mounted the linear actuator properly (p. 15) and have connected the protective earth conductor (p. 22).
- ✓ You have installed a suitable controller (p. 12).
- ✓ You have read and understood the user manual of the controller.

### Connecting the N-111 to the controller

1. Connect the connector of the linear actuator to the corresponding socket of the controller (see user manual of the controller).
2. Secure the connection with the integrated screws against accidental disconnection.
3. Eliminate or label resulting danger areas in accordance with the valid regulations and recommendations.

# 6 Start-Up and Operation

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## 6.1 General Notes on Start-Up and Operation

***CAUTION***

**Risk of electric shock if the protective earth conductor is not connected!**

If a protective earth conductor is not or not properly connected, dangerous touch voltages can occur on the N-111 in the case of malfunction or failure of the system. If touch voltages exist, touching the N-111 can result in minor injuries from electric shock.

- Connect the N-111 to a protective earth conductor before start-up (p. 22).
- Do **not** remove the protective earth conductor during operation.
- If the protective earth conductor has to be removed temporarily (e. g. in the case of modifications), reconnect the N-111 to the protective earth conductor before starting it up again.

***CAUTION***

**Dangerous voltage and residual charge on piezo actuators!**

The N-111 is driven by piezo actuators. Temperature changes and compressive stresses can induce charges in piezo actuators. After being disconnected from the electronics, piezo actuators can also stay charged for several hours. Touching or short-circuiting the contacts in the connector of the N-111 can lead to minor injuries. In addition, the piezo actuators can be destroyed by an abrupt contraction.

- Do **not** open the N-111.
- Do **not** touch the contacts in the connector of the linear actuator.
- Secure the connector of the linear actuator with screws against being pulled out of the controller.

If you want to pull out the connector of the linear actuator:

- Do **not** pull out the connector from the controller during operation.
- Discharge the linear actuator **before pulling out the connector (p. 30).**
- If possible: Switch off the controller and wait at least 10 seconds **before pulling out the connector**.

***NOTICE***

**Heating up of the N-111 during operation!**

The heat produced during operation of the N-111 can affect your application.

- Install the N-111 so that your application is not affected by the dissipating heat.

***NOTICE***

**Uncontrolled oscillation!**

Your application and the N-111 can be damaged by uncontrolled oscillations. Uncontrolled oscillations can be identified by the fact that the linear actuator approaches the target position too slowly or too fast or does not keep it stable (servo jitter).

If uncontrolled oscillations occur during the operation of the N-111:

- Immediately switch off the servo-control system of the affected axis.
- Check the settings of the servo-control parameters.

***NOTICE***

**Increased friction due to lateral forces on the rod!**

Lateral forces that act on the rod of the N-111 increase the friction between the rod and internal drive components. Increased friction impairs the motion of the rod and increases the wear of the drive components.

➢ Avoid lateral forces on the rod of the N-111.

***INFORMATION***

For sending commands to the linear actuator, the outward motion of the rod is defined as positive direction of motion.

***INFORMATION***

In the ideal application case, the linear actuator is operated quasi-statically. In quasi-static operation, the load is mainly kept at a particular position and only temporarily positioned (stepping mode).

For the N-111.2A1, the following also applies:

***INFORMATION***

The repeatability of the positioning is only ensured when the reference point switch is always approached from the same side. Recommended controllers from PI fulfill this requirement with their automatic direction detection for reference moves to the reference point switch.

## 6.2 Operating the N-111

### Prerequisites

✓ You have read and understood the user manual of the controller.

✓ You have read and understood the user manual of the PC software.

✓ You have properly mounted the linear actuator (p. 15) and connected the protective earth conductor (p. 22).

✓ The controller and the required PC software have been installed. All connections with the controller have been established (see user manual of the controller).

### Operating the N-111

➢ Follow the instructions in the manual of the controller used for startup and operation of the N-111.

## 6.3 Discharging the N-111

The N-111 must be discharged in the following cases:

- When the N-111 is not used but the controller remains switched on to ensure temperature stability
- Before pulling out the connector of the N-111 (e. g. before demounting (e.g. before cleaning and transport of the N-111 and for modifications of the application)

### Discharging the N-111

1. If you are working in closed-loop operation: Switch off the servo mode on the controller.
2. Set the piezo voltage to 0 V on the controller.
3. If you want to disconnect the N-111 from the controller:
   - If possible: Switch off the controller.
   - Wait at least 10 seconds before disconnection

# 7 Maintenance

## In this Chapter

General Notes on Maintenance ..... 31
Cleaning the N-111 ..... 31

## 7.1 General Notes on Maintenance

**NOTICE**

**Damage due to improper maintenance!**

The linear actuator can become misaligned as a result of improper maintenance. The specifications can change as a result (p. 37).

➢ Only loosen screws according to the instructions in this manual.

## 7.2 Cleaning the N-111

### Prerequisites

✓ You have discharged the piezo actuators of the N-111 (p. 30).

✓ You have disconnected the N-111 from the controller.

### Cleaning the N-111

➢ Clean the surfaces of the N-111 with a cloth that is slightly dampened with a mild cleanser or disinfectant (e.g. ethanol or isopropanol).

➢ Do **not** do any ultrasonic cleaning.

# 8 Troubleshooting

| Problem | Possible Causes | Solution |
|---|---|---|
| Target position is approached too slowly or with overshoot | ▪ Servo-control parameters are not optimally set<br>▪ Large changes in the load | 1. Switch off the servo-control system immediately.<br>2. Check the settings of the servo-control parameters.<br>3. If necessary, correct the settings of the servo-control parameters. |
| Target position is not kept stable | | |
| Uncontrolled oscillations of the N-111 | | |
| Increased wear | Excessive lateral forces on the rod | ➢ Avoid lateral forces on the rod of the N-111. |
| Reduced accuracy | | |
| No or limited motion | ▪ Excessive load<br>▪ Excessive counterforces in the direction of motion | ➢ Reduce the load (see "Mechanical Load Capacity" (p. 40)).<br>In the case of vertical mounting:<br>➢ Ensure gravity compensation so that the maximum load (p. 40) is not exceeded. |

If the problem that occurred with your system is not listed in the table above or cannot be solved as described, contact our customer service department (p. 35).

# 9 Customer Service

For inquiries and orders, contact your PI sales engineer or send us an e-mail (mailto:info@pi.ws).

- If you have questions concerning your system, have the following information ready:
  - Product codes and serial numbers of all products in the system
  - Firmware version of the controller (if present)
  - Version of the driver or the software (if present)
  - Operating system on the PC (if present)
- If possible: Take photographs or make videos of your system that can be sent to our customer service department if requested.

The latest versions of the user manuals are available for download (p. 3) on our website.

# 10 Technical Data

## In this Chapter

Specifications ..... 37
Maximum Ratings ..... 39
Mechanical Load Capacity ..... 40
Dimensions ..... 42
Pin Assignment ..... 44

## 10.1 Specifications

### 10.1.1 Data Table

| | N-111.201 | N-111.2A1 | Unit | Tolerance |
|---|---|---|---|---|
| Active axes | X | X | | |
| **Motion and positioning** | | | | |
| Travel range | 10 | 10 | mm | |
| Step size (in step mode) | 10 nm to 7 µm | 10 nm to 7 µm | | |
| Travel range in analog mode | ±2 | ±2 | µm | |
| Integrated sensor | – | Linear encoder | | |
| Open-loop resolution | 0.025 | 0.025 | nm | typ. |
| Closed-loop resolution | – | 5 nm | | |
| Velocity (10 % duty cycle, full step mode)* | 1.0 | 1.0 | mm/s | max. |
| Velocity (100 % duty cycle, full step mode)* | 0.6 | 0.6 | mm/s | max. |
| Velocity (100 % duty cycle, nanostepping mode)** | 0.4 | 0.4 | mm/s | max. |
| **Mechanical properties** | | | | |
| Stiffness in motion direction | 16 | 16 | N/µm | ±20 % |
| Drive force (active)*** | 50 | 50 | N | max. |
| Holding force (passive) | 70 | 70 | N | min. |
| **Drive properties** | | | | |
| Motor type | NEXLINE® | NEXLINE® | | |
| Operating voltage | ±250 | ±250 | V | |

| Miscellaneous | N-111.201 | N-111.2A1 | Unit | Tolerance |
|---|---|---|---|---|
| Operating temperature range | -40 to 80 | -40 to 80 | °C | |
| Material | Aluminum, stainless steel, titanium | Aluminum, stainless steel, titanium | | |
| Mass | 245 | 325 | g | |
| Cable length | 1.5 | 1.5 | m | ±10 mm |
| Connector | Sub-D 25 | Sub-D 25 | | |
| Recommended controllers | E-712.1AM | E-712.1AM | | |

Ask about custom designs!

* Depending on drive electronics.Data refer to operation with E-712 controller

** Depending on drive electronics.Data refer to operation with E-712 controller. The maximum velocity in nanostepping mode is designed for the best possible constancy so that no velocity variations occur when executing the steps.

*** Data refer to operation in full step mode.

## 10.1.2 Ambient Conditions and Classifications

The following ambient conditions and classifications must be observed for the N-111:

| | |
|---|---|
| Area of application | For indoor use only |
| Maximum altitude | 2000 m |
| Air pressure | 1100 hPa to 0.1 hPa |
| Relative humidity | Highest relative humidity 80% for temperatures to 31°C, non-condensing<br>Decreasing linearly to 50% relative humidity at 40 °C, non-condensing |
| Operating temperature | -40°C to 80°C |
| Storage temperature | -40°C to 80°C |
| Transport temperature | -40°C to 80°C |
| Overvoltage category (in acc. with EN 60664-1:2007 / VDE 0110-1) | II |
| Protection class (acc. to EN 61140 / VDE 0140-1) | I |

| | |
|---|---|
| Degree of pollution (acc. to EN 60664-1:2007 / VDE 0110-1) | 1 |
| Degree of protection (acc. to IEC 60529) | IP20 |

## 10.2 Maximum Ratings

The N-111 is designed for the following maximum ratings:

| **Operating Mode** | **Maximum Operating Voltage** | **Maximum operating frequency or velocity (unloaded)** | **Maximum power consumption*** |
|---|---|---|---|
| Analog mode | +250 V; -250 V | 700 Hz | 1.65 W** |
| Full step mode | | 600 µm/s | 2.6 W |
| Nanostep-ping mode | | 400 µm/s | |

* for dynamic continuous operation (**not** recommended!)

** at full amplitude and a max. frequency of 250 Hz

# 10.3 Mechanical Load Capacity

## Maximum values for torque and forces

Negative values in the table correspond to a reversal of the effective direction according to the following figure.

| Parameter | Permissible Values |
|---|---|
| Passive force (holding force, linear actuator currentless) $F_h$ | - 70 N to 70 N |
| Active force (drive force) $F_p$ | - 50 N to 50 N |
| Lateral force $F_l$ | - 5 N to 5 N |
| Torque $M_{rot}$ in the direction of the rod axis | - 0.2 Nm to 0.2 Nm |
| Torque $M_l$ generated by lateral force (radial; not shown) | - 0.15 Nm to 0.15 Nm |

The following figure shows the directions of acting forces and torques as examples. Depending on the orientation of the setup, effects of gravity must be included in the calculation.

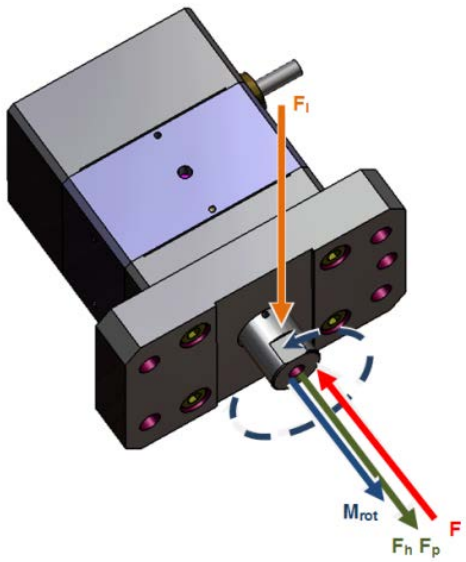



*Figure 14: Forces and torques potentially affecting the rod (schematic)*

*$F_p$: Active force (direction for forward motion of the rod) or*
*$F_h$: Holding force (when the rod is at rest)*
*F: Force generated by load (positioning or holding)*
*$F_l$: Lateral force*
*$M_{rot}$: Torque (e.g. in the case of load mounting;*
*dashed: direction of action of the causal force)*

## Velocities and step sizes when the drive is loaded

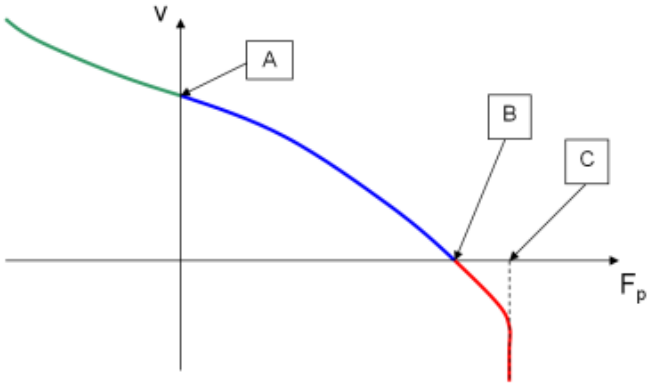



*Figure 15: Velocity v as a function of the active force $F_p$ (qualitative)*

*$F_p$: Active force*
*v: Velocity of the rod*
*Special conditions:*
*A: No load*
*B: Stop*
*C: Slippage*

With increasing mass of the load (and thus the active force to be generated), the achievable step size of the drive elements and thus also the maximum velocity of the rod decrease (see explanations of the operation of the NEXLINE drive in the manual of the controller). The relationships are qualitatively shown in the above diagram.

In the unloaded state (point A), maximum step size and velocity are attained for horizontal mounting of linear actuator and load when no pull force acts in the direction of the rod axis.

Pull forces acting on the rod (e.g. gravity in the case of vertical mounting or, in relation to the horizontal line, inclined mounting of the system) can support the rod motion and cause the velocity to increase further (area left of point A).

On the contrary, the linear actuator applies the maximum active force to compensate for the maximum permissible load (point B). In this state, the velocity drops to 0.

In the currentless state of the linear actuator, the rod is clamped (holding force; generated by the preloaded piezo assemblies). Consequently, the position of a coupled load is held with a permissible load. If the holding force is overcompensated by an impermissibly high load, the clamping effect of the piezo assemblies on the rod is lost (slippage, point C).

Compared to the velocity, analog conditions result for the step sizes in normal operation (see graph, range to the left of B).

# 10.4 Dimensions

## 10.4.1 N-111.201

Dimensions in mm. Note that the decimal places are separated by a comma in the drawings.

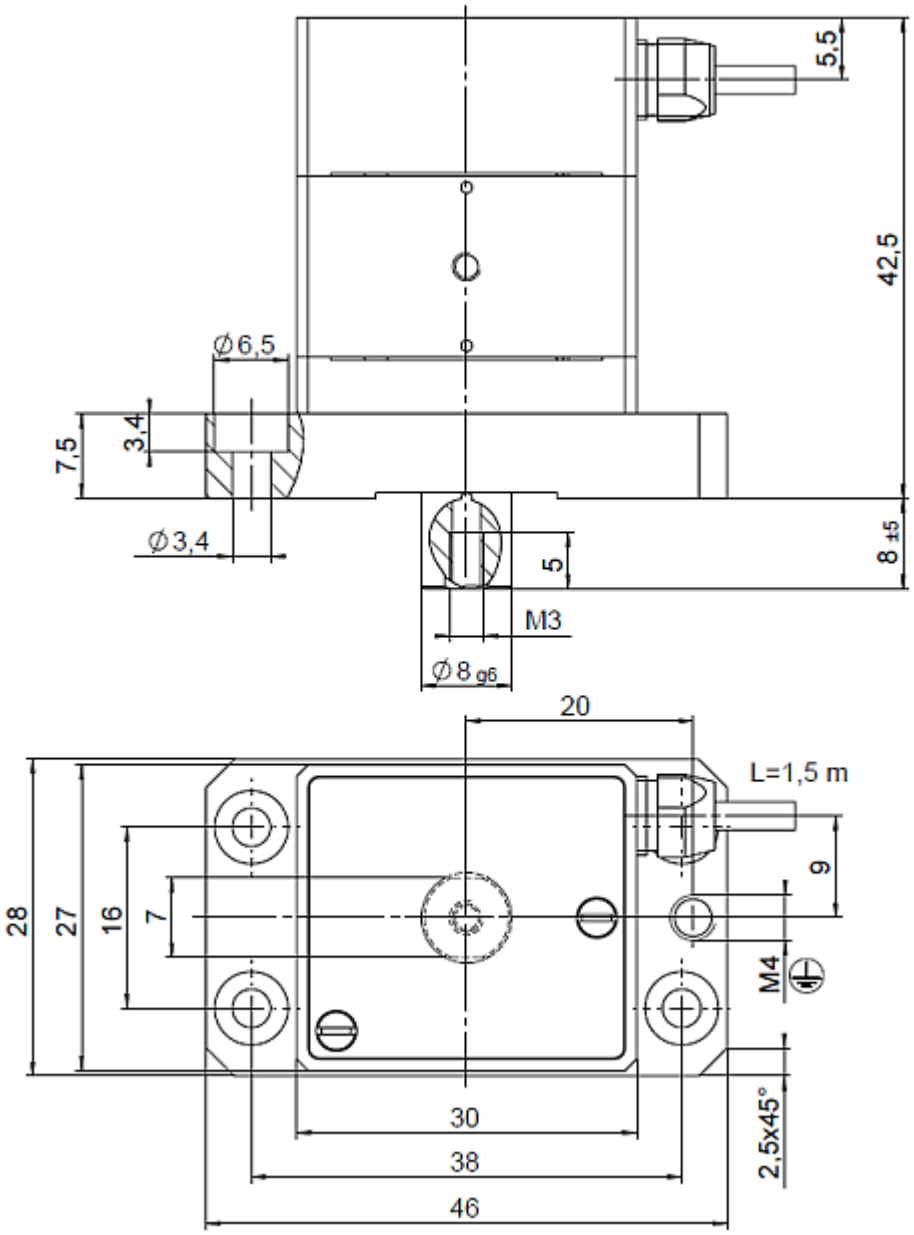



*Figure 16: N-111.201 dimensions, rod at center position*

## 10.4.2 N-111.2A1

Dimensions in mm. Note that the decimal places are separated by a comma in the drawings.

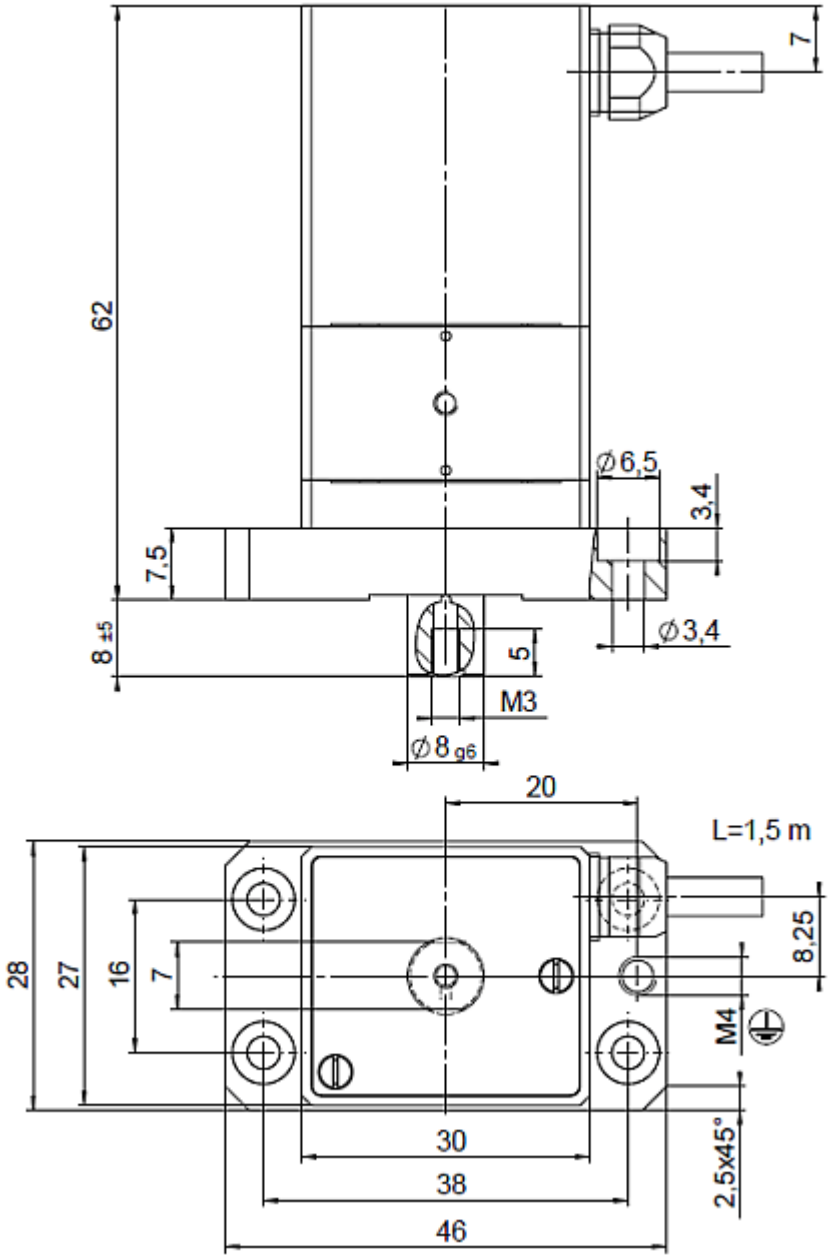



*Figure 17: N-111.2A1 dimensions, rod at center position*

# 10.5 Pin Assignment

## 10.5.1 N-111.201

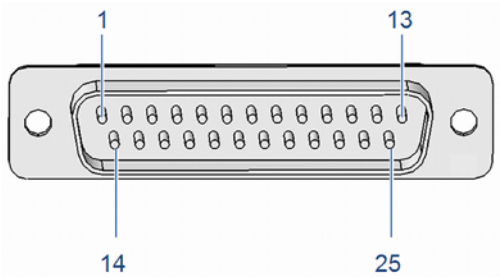



*Figure 18: Sub-D 25 connector*

| Pin | Signal* | Function | Direction |
|---|---|---|---|
| 1 | D1+ | Supply voltage for shearing group 1 (-250 V to 250 V) | Input |
| 2 | - | | |
| 3 | - | | |
| 4 | D2+ | Supply voltage for shearing group 2 (-250 V to 250 V) | Input |
| 5 | - | | |
| 6 | - | | |
| 7 | - | | |
| 8 | - | | |
| 9 | - | | |
| 10 | C+ | Supply voltage for clamping group (-250 V to 250 V) | Input |
| 11 | - | | |
| 12 | - | | |
| 13 | - | | |
| 14 | - | | |
| 15 | D1- | Ground of shearing group 1 | |
| 16 | - | | |
| 17 | - | | |
| 18 | D2- | Ground of shearing group 2 | |
| 19 | - | | |

| Pin | Signal* | Function | Direction |
|---|---|---|---|
| 20 | - | | |
| 21 | - | | |
| 22 | - | | |
| 23 | - | | |
| 24 | C- | Ground of clamping group | |
| 25 | - | | |

* The "-" sign indicates that the corresponding pin has not been assigned.

## 10.5.2 N-111.2A1

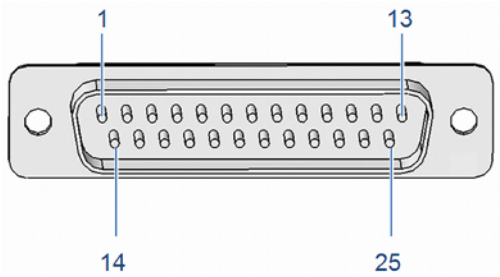



*Figure 19: Sub-D 25 connector*

| Pin | Signal* | Function | Direction |
|---|---|---|---|
| 1 | D1+ | Supply voltage for shearing group 1 (-250 V to 250 V) | Input |
| 2 | +5V (sensor) | Supply voltage for encoder | Input |
| 3 | +5V (ref) | Supply voltage for reference point switch | Input |
| 4 | D2+ | Supply voltage for shearing group 2 (-250 V to 250 V) | Input |
| 5 | - | | |
| 6 | - | | |
| 7 | - | | |
| 8 | GND (sensor) | Encoder ground | |
| 9 | GND (ref) | Ground of reference point switch | |
| 10 | C+ | Supply voltage for clamping group (-250 V to 250 V) | Input |

| Pin | Signal* | Function | Direction |
|---|---|---|---|
| 11 | - | | |
| 12 | Ref- | Reference point switch | Output |
| 13 | Ref+ | Reference point switch | Output |
| 14 | - | | |
| 15 | D1- | Ground of shearing group 1 | |
| 16 | Sin+ | Encoder signal 1 (sine) | Output |
| 17 | Sin- | Encoder signal 1 (sine) | Output |
| 18 | D2- | Ground of shearing group 2 | |
| 19 | Cos+ | Encoder signal 2 (cosine) | Output |
| 20 | Cos- | Encoder signal 2 (cosine) | Output |
| 21 | - | | |
| 22 | - | | |
| 23 | - | | |
| 24 | C- | Ground of clamping group | |
| 25 | - | | |

* The "-" sign indicates that the corresponding pin has not been assigned.

# 11 Old Equipment Disposal

In accordance with EU law, electrical and electronic equipment may not be disposed of in EU member states via the municipal residual waste.

Dispose of your old equipment according to international, national, and local rules and regulations.

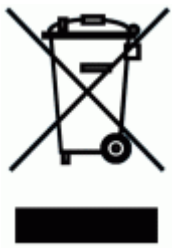
In order to fulfil its responsibility as the product manufacturer, Physik Instrumente (PI) GmbH & Co. KG undertakes environmentally correct disposal of all old PI equipment made available on the market after 13 August 2005 without charge.

Any old PI equipment can be sent free of charge to the following address:

Physik Instrumente (PI) GmbH & Co. KG

Auf der Roemerstr. 1

D-76228 Karlsruhe, Germany



# 12 EC Declaration of Conformity

For the N-111, an EC Declaration of Conformity has been issued in accordance with the following European directives:

2006/95/EC, Low Voltage Directive

2004/108/EC, EMC Directive

2011/65/EU, RoHS Directive

The applied standards certifying the conformity are listed below.

Safety (Low Voltage Directive): EN 61010-1:2010

EMC: EN 61326-1:2013

RoHS: EN 50581:2012